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Metrics Concept Report

Central Archive for Reusable Defense Software (CARDS)

Informal Technical Report

CARDS

Central Archive for Reusable Defense Software

STARS-VC-B019/004/00
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INFORMAL TECHNICAL REPORT
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SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS
(STARS)

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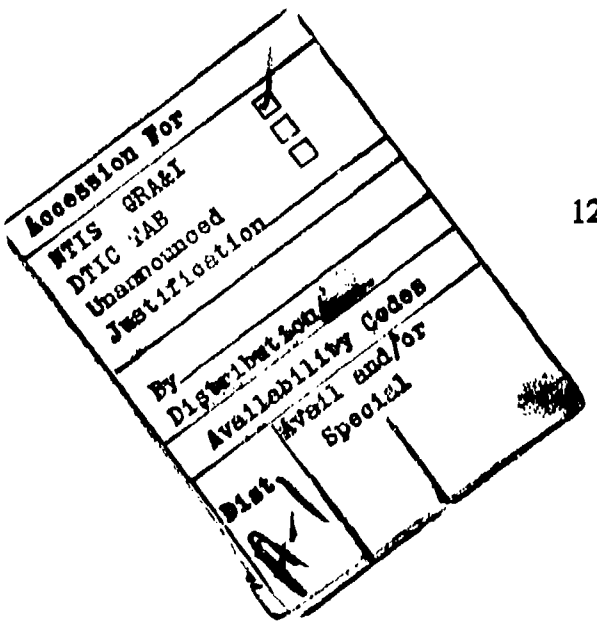

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INFORMAL TECHNICAL DOCUMENT
Metrics Concept Report
Central Archive for Reusable Defense Software
(CARDS)

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INFORMAL TECHNICAL REPORT
Metrics Concept Report

ABSTRACT

In February 1993 the Defense Information Systems Agency/Center for Information Management (DISA/CIM) sponsored a Software Reuse Metrics Workshop. The primary goal of these meetings was to develop a set of questions that would indicate what measurements should be collected in support of the DISA/CIM Software Reuse Program. The results of this workshop are published in the DISA/CIM Software Reuse Program Reuse Metrics Workshop Proceedings, 23-24 February 1993 [DISA93].

These proceedings indicate that DISA/CIM's Software Reuse Metrics Plan will be used as a foundation for developing a DoD Software Reuse Metrics Plan. The DISA/CIM plan serves as a major input into the DoD-wide plan, and DISA/CIM will be conducting pilot prototypes of their recommendations.

The CARDS (Central Archive for Reusable Defense Software) metrics effortsshould also provide valuable information that can be feed into the DoD-wide Software Reuse Metrics Plan. As stated in the DoD Software Vision and Strategy Document, the DoD must establish a baseline upon which to gauge success and measure improvement that serve as a basis for comparison among alternative approaches.

Therefore, the CARDS metrics effort is two-fold: (1) use metrics within the CARDS Program to measure and improve processes, products, and services and (2) monitor and provide possible contributions to the DoD Software Reuse Metrics Plan. The Metrics Concept Report focuses mostly on metrics within CARDS. As experience is gained within the CARDS Program, more effort will be focused towards the development of input for the DoD Software Reuse Metrics Plan. However, decisions will be made in support of the larger DoD-wide perspective.

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Table of Contents

Metrics Concepts Report

1 Purpose and Intended Audience of the Metrics Concepts Report

This document provides a framework for defining and implementing a *measurement process* for the CARDS Program, its processes, products, and services.

The intended audience of this document is the CARDS Program Manager, System Architect, Franchise Coordinator, Project Leads, and all other CARDS team members. Readers outside the CARDS organization should be familiar with the CARDS Program, its terminology and organization. Suggested readings are listed in the reference section.

1.1 Structure of this Document

The *Introduction* Section describes how metrics flow within the CARDS Program, outlines the goals of the CARDS measurement process, and briefly describes Victor Basili's Goal/Question/Metric (GQM) paradigm.

The *CARDS Environment* Section focuses on the challenges produced by the CARDS environment: the organizational structure, the CARDS Program, the implementation of franchises, and the readiness of the CARDS organization for metrics.

The *Measurement Process* Section describes a six-step process and a matrix framework that will be used to relate metrics back to their originating questions, issues, and/or goals.

The *Metrics Definition Phase* Section explains the first three steps of the six-step process: defining goals, defining processes, and defining metric questions and metrics.

The *Metrics Implementation Phase* Section describes the last three steps of the six-step process: collecting the metrics, analyzing the metrics, and acting on the results of the analysis.

The *Added Value through Automation* Section describes a database tool to document the metrics and facilitate analysis.

1.2 Relationship to Other CARDS Documents

The measurement process will first be applied to the CARDS Command Center Library (CCL) and documented in a *Metrics Plan*. Lessons learned will be used to refine the measurement process before possibly expanding it to other CARDS project areas (domain engineering, franchise implementation, franchise concepts, training, and reuse coordination).

All metrics definition, collection, analysis, and presentation procedures created will be documented in the *CARDS Library Operation Policies and Procedures Manual* (LOPP).

2 Introduction

A metric is a characteristic (such as lines of code, number of defects, or defects/lines of code) of a process, service, or product. Metrics are useful for indicating where a process, service, or product can be improved, or when a goal has been met. The definition, collection, and analysis of metrics is a cyclical process. Lessons learned from metrics information can lead to modifications in the CARDS Program and project goals, which may result in refinement of the processes. For a measurement process to provide benefits to a project, the definition, collection, and analysis of metrics must be guided by carefully identifying appropriate goals.

The metrics addressed in this Metrics Concept Report are closely aligned with the principles of Total Quality Management (TQM) and Continuous Process Improvement. This chapter describes the flow of metrics information within CARDS, lists the measurement goals for CARDS, and briefly describes the GQM paradigm as defined by Victor Basili for systematically eliciting metrics [24].

2.1 Metrics flow in the CARDS Program

For a measurement process to be effective, it needs to be an integral part of the decision-making process within the CARDS Program. Figure 2-1depicts the interaction and flow of metrics within the CARDS Program.

On the left hand side of the figure, a generalized representation of CARDS is shown. Starting at the top left, the Customer Goals provide context for the development of the CARDS Program Goals. Customer Goals are stated in the DoD Software Reuse Vision and Strategy [8], by ENS, and in the HAC Operating Goals and Principles [9]. These goals in turn direct the CARDS team in the development and execution of the activities or processes that constitute the existence of CARDS. The processes ultimately result in CARDS products and services for CARDS users.

The metrics flow is shown on the right hand side of the figure.

1. Metrics definition draws on the CARDS Program Goals, the processes implemented by the CARDS team, and the products and services offered to CARDS users.
2. The metrics definition determines the collection, analysis, and presentation of metrics data.
3. Analysis and presentation of the metrics data will determine what findings are to be implemented. The metrics findings and the changes implemented may result in providing input for changes into Customer Goals as they apply to reuse metrics, CARDS Program Goals, processes and/or products, and/or the metrics definition.

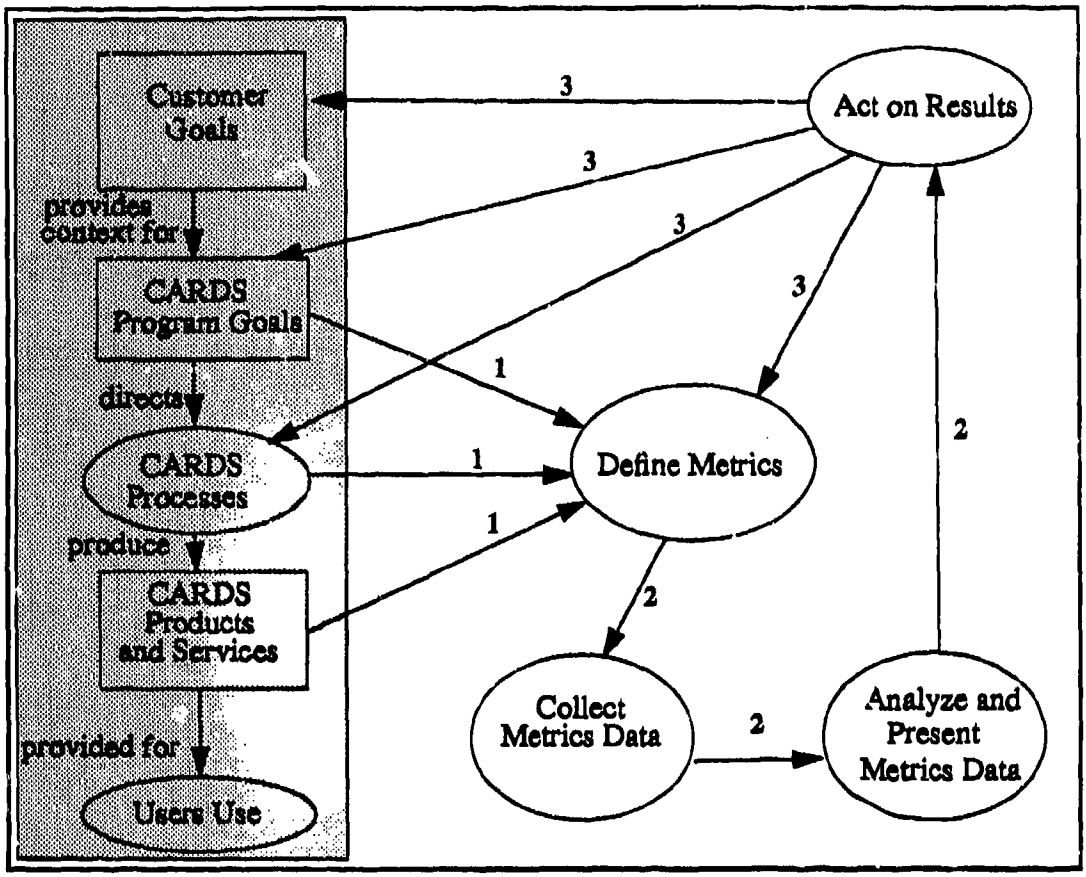

Figure 2-1. Interaction of Metrics within CARDS

2.2 CARDS Program-Wide Metrics Goals

For a measurement process to be successful, it must be guided by well-defined goals. The metrics goals for the CARDS Program are to:

1. Monitor the productivity and/or quality of a process, product, and/or service by:
   a. determining trends CARDS is interested in;
   b. identifying what CARDS has implemented or intends to implement for productivity improvements (such as tool usage and process improvement);
   c. validating accepted policies and procedures or indicate areas to change; and
   d. determining root causes for defects.
2. Provide visibility into projects for Program Management by:
   a. projecting the impact of resource allocation and reallocation;
   b. tracking the effect of events on processes and products; and
   c. maintaining an ongoing profile/summary of CARDS activities.

3. Generate presentable quality metrics to promote CARDS within the DoD and other Government agencies, as well as within industry.

2.3 Goal/Question/Metric Paradigm

The GQM paradigm provides a basis for defining and evaluating a set of operational goals using measurement. This paradigm can be applied to each goal, process, product, and service offered by CARDS.

The GQM paradigm defined by Victor Basili [24] uses a top-down approach to identifying and interpreting metrics. To implement this model an organization should:

- specify the goals for itself and its projects;
- trace goals to the data needed to quantify these goals operationally; and
- provide a framework for analyzing the data in the context of the goals.

As shown in Figure 2-2, the flow from the goals to the metrics in the GQM paradigm can be viewed as a directed graph. The flow is from the goal nodes, to the question nodes, to the metric nodes. Each goals generates a set of quantifiable questions. Each question, in turn, generates a set of metrics (mi, i= 1,2,...n). The same questions can be used to define multiple goals, and several related metrics may be needed to provide the answer to one question.

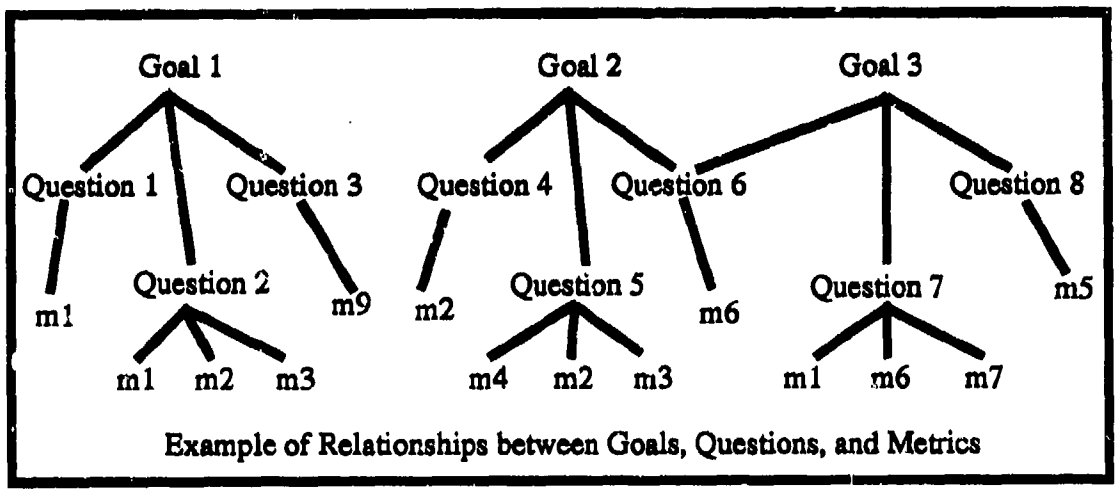

Figure 2-2. Goals, Questions, and Metrics

3 CARDS Environment

The development and implementation of metrics for the CARDS Program is affected by the need for DoD-wide metrics, the organizational structure of the CARDS team, the CARDS Program with its processes, products, and services, and the establishment of franchises. This chapter describes the challenges faced in these environments and assesses the readiness of the CARDS team for implementing the measurement process.

3.1 DoD-Wide Metrics

The DoD Software Reuse Initiative [9] states this principle for metrics:

- "*Measure Results in terms of customer satisfaction.* Customer success produces solid referrals, and customer referrals are the strongest way to diffuse technology. Defining success in customer terms will focus and integrate the activities of all SRI staff members".

The CARDS team should design surveys on user satisfaction that provide quantitative feedback on CARDS products and services.

The DISA/JIEO/CIM Software Reuse Metrics Plan [7] also suggests several metrics that should be collected by

- the DoD Program/Project Manager on the products and services provided by CARDS. These metrics should be fed to the CARDS Program; and
- the CARDS Repository Manager on the CARDS Library System.

Use of these metrics will help provide more focused and effective services to users throughout the DoD, measure the payoff from the reuse initiative, aid developers in the selection of reusable components, and provide documented evidence for successful, frequent reuse.

3.2 Organizational Structure

The CARDS Program is composed of multiple contractors with personnel from different companies working on the same tasks. Different management tools and techniques are used to collect and report on data within each company. One example of this practice is the timesheet recording mechanism. At the macro level each company charges to the eleven CARDS task areas, while at the micro level freedom is given for a finer breakdown in recording the actual work performed for each task, the layout of the timesheets, the collection schedule, etc. For a measurement process to be successful, consistent methods must be devised to compensate for these and other differences in data collection and reporting.

3.3 CARDS Program

3.3.1 CARDS Processes

The processes that create, refine, and transfer CARDS technology are being developed and implemented simultaneously by the CARDS team. These processes are at various stages of stability. Some processes are still being developed (such as the CARDS organization assessment process), while others have reached stability (such as the Library Administration processes).

Metrics will be most effective once processes have become stable. Metrics collected in an unstructured environment do not provide data that can be compared to either a standard or to another process in another environment. Too many variables affect the data to make evaluation useful. Table 1 describes when a process is deemed stable enough for metrics definition and collection to be effective.

Table 1: Process Metric Qualification

Process is...	Candidate for metric collection....
now being defined	immature
not documented	premature
documented, but changing	qualifies
stable, repeatable, used, and documented	qualifies

Processes that are being defined or that are undocumented (and thus difficult to repeat) are not qualified for metrics definition. However, changing, documented processes are qualified because a baseline measurement can be taken to establish a starting point for improvement. The improvements suggested will themselves result in changes to process steps. These changes must be measured to ensure that any change which is implemented produces the desired improvement, and to measure the possible impact of the change on other steps of the process. Stable, repeatable processes are also qualified for metrics collection which will help ensure that the processes remain stable and efficient.

The metrics challenge for the CARDS team will be to evolve the measurement process as CARDS processes mature. One-time activities such as the initial learning curve, changing processes due to a change in direction, or experimenting with process steps should be eliminated from metrics collection. They should be separated from repeat activities, such as qualifying a component, installing a component in the CARDS Library System, or providing training to a prospective franchise, which will be measured.

3.3.2 CARDS Products

Products provided by the CARDS Program are the CARDS Library System and its contents.The CARDS Library System currently consists of three libraries: the Command Center Library (CCL), the PRISM Distribution Library (PDL), and the CARDS Documentation Library (CDL).

3.3.2.1 The CCL

The CARDS CCL consists of reusable components at multiple levels of abstraction, including architectures, requirements, subsystems, and individual components. Given the model-based approach, the CCL places as much emphasis on the complex relationships among components as it does on the quality of the components themselves. One aspect of the CARDS CCL that can be used for metrics development is the domain-specific software architecture, which serves as a basis for "qualifying" reusable components for the library.

Metrics collected on CCL components should take into account the component's various implementations. Qualification criteria to determine if a component is "fit for use" should be established for each domain. Certification criteria to recommend "best of class" should be established for selected compo-

nents. Quality factors (such as Reliability, Maintainability, Usability, Portability, Security, and Performance), their priority, and their respective target values must be established so components can be evaluated and compared objectively. The metrics challenge for the CARDS team will be to define and collect metrics during and after the development/evaluation of these components to determine how closely a particular component meets its expected target. Metrics should also be collected from CCL users as individual components are extracted and used, to identify user preferences, needs, and wants. This data can be used to tailor the contents of the CCL. Metrics collected on the "infrastructure" of the CCL (the semantic network and the RLF browser) will be useful when planning for improvements to the user interface and the speed of tool response.

3.3.2.2 The PDL and CDL

The PDL contains PRISM documents such as quarterly demonstration reports and software development plans and will shortly also contain wrappers (interface software). The CDL will contain all CARDS reusable documentation components such as the Library Development Handbook and the LOPP. Quality factors for these products should be established so measurement can help to determine their Usability and Reliability.

3.3.3 CARDS Services

CARDS services exist within two categories: services targeted at franchises and services targeted a specific user, as well as services provided to "spread the word" about reuse technology gained by CARDS. Examples of services provided to franchises and users are organization analysis, Hotline support, and training seminars. Examples of services provided to "spread the word" are writing, submitting, and presenting papers, working with universities, doing demos, and attending trade shows.

The metrics challenge for the CARDS team will be to construct user surveys that provide *quantitative* feedback on CARDS products and services. These surveys allow the team to compare user expectations with user satisfaction to gauge the overall effectiveness of the services provided by CARDS.

Services provided to "spread the word" will help generate interest in reuse technology and thus result (hopefully) in more franchises, users, and students who are familiar with reuse technology. Many of these benefits are long term, and some are impossible to ascertain (what metric value to attribute to "word-of-mouth" advertising resulting in a new franchise for example.) Due to the expected difficulty of collecting *quantifiable* benefits on these activities, it is recommended not to measure these latter services.

3.4 Franchise Implementation

To fulfill the mission of technology transfer, the CARDS Program is establishing franchises with federal agencies to facilitate the infusion of technology developed by the CARDS team and other reuse researchers. The CARDS team is defining concepts, strategies, and plans (such as the reuse adoption handbook and/or the franchise plan [11]) essential to supporting reuse via franchising.

Franchises will provide CARDS with knowledge about their reuse experience. This knowledge can be provided into CARDS processes, an/or additional domain expertise in the form of new components. The metrics challenge for the CARDS team will be to define and collect metrics from each franchise to de-

termine the benefit of reuse adoption. The team should also measure the improvements resulting from process feedback, measure the cost to CARDS associated with defining the concepts, strategies, and plans, and provide a method to CARDS Program Management that helps allocate the cost metrics to each franchise.

Franchise organizations will also look to CARDS for guidance on defining metrics for their own products, processes, and services to determine their own cost/benefit ratio for implementing a reuse technology. Metrics should be defined that help prospective franchises determine the start-up costs of building a reuse library.

3.5 Assessing the CARDS Measurement Process

To assess the readiness of the CARDS team for a measurement process, the framework to evaluate a measurement process proposed by Jeffery & Berry [10] can be used. The framework evaluates the *context* in which a measurement process is developed and operated, the *process* used to develop, implement, and maintain the measurement process, and the *product* produced by the measurement process, such as the reports produced. This framework could be used repeatedly to determine quantitatively how the use of metrics at CARDS is improving. The evaluation questions and comments are shown in tables 1, 2, and 3 in Appendix A.

Preliminary investigations using Jeffery's framework produced these observations:

- The environment in which the CARDS measurement process is being developed and operated is constantly changing. The CARDS team is working to establish stable goals and objectives, and to document processes. Some metrics are currently being collected in the Library Operations project area. As CARDS moves towards "proof-of-concept" other project areas will also be stabilizing their processes. The metrics analysts must be involved with the process definition to ensure that process steps do not hinder the metrics collection.
- The metrics themselves do not currently provide clear benefits to management. Metrics collected in the Library Operations project area must be reevaluated to determine *why* specific metrics are being collected. The next chapter outlines a set of matrices that help trace goals to metrics. Lessons learned during the definition and collection of metrics for Library Operations should be applied to the development and implementation of metrics in other project areas.
- Automation of the methods used to define, analyze, report, and maintain CARDS metrics is needed. Manual data collection and evaluation is labor intensive, time consuming, and error prone. Tools to automatically collect product data and generate a metrics database are needed for the long term success of the measurement process. While Library Operation has developed scripts to help collect some of the data, a concentrated effort is needed to evaluate and recommend a tool and database for the CARDS measurement process.

4 The Measurement Process

The measurement process is a dynamic method of measuring, assessing, and adjusting products, processes, and services using objective data. Metrics are collected on a known or anticipated issue, concern, or question. Metrics are analyzed with respect to the characteristics of the product, process, or service and are used in turn to assess their respective progress, quality, and performance throughout development.

This chapter outlines a six-step process to identify CARDS Program goals, processes, associated metric questions, and metrics; and to collect, analyze, and act on the results of the metrics. This chapter also describes a set of matrices within the measurement process.

4.1 Process Overview

The measurement process is dependent on CARDS goals, processes, products, and services that are to be measured. Improving processes, products and/or services requires continual evaluation of past experiences, repeated evaluation, and refinement of the processes used to produce the products and/or services.

The six-step process for defining and implementing metrics is illustrated in Figure 4-1. This measurement process is based on industry experience and has been tailored to the CARDS Program.

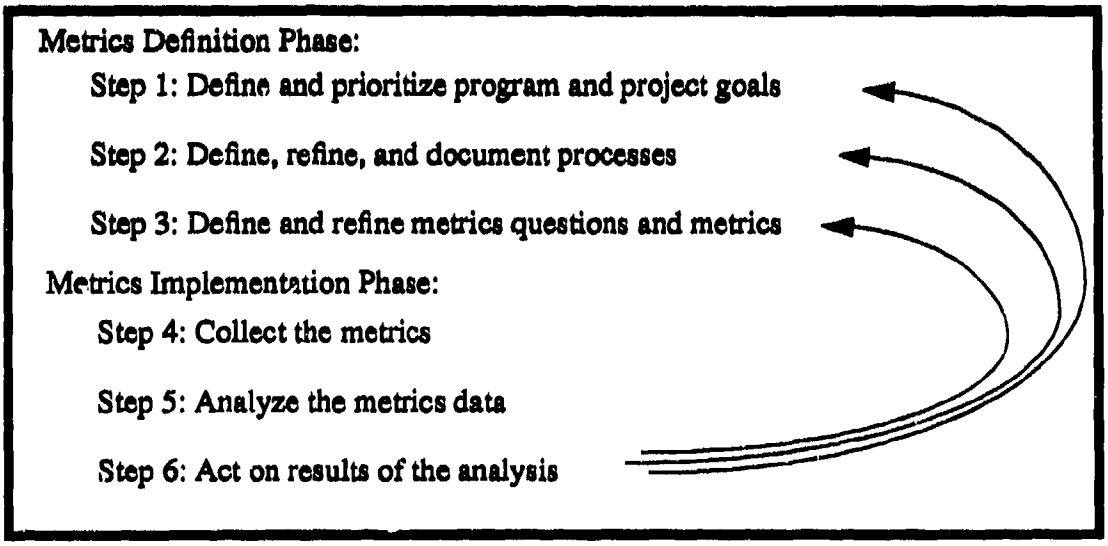

Figure 4-1. The Measurement Process

The measurement process is divided into the Metrics Definition Phase (defining goals, processes, and metrics) and the Metrics Implementation Phase (collecting, analyzing, and acting on metrics results). The Metrics Definition Phase is detailed in chapter five. The Metrics Implementation Phase is detailed in chapter six. The arrows in Figure 4-1 show how the measurement process is cyclical. Acting on the results of the analysis in Step six may mean refining definitions from Steps one, two and/or three.

4.2 The Matrix Framework

A set of goal, process, and metric matrices were constructed as a framework for documenting and directing the Metrics Definition Phase. These matrices are illustrated in Figure 4-2.

4.2.1 The Goal Matrices

Goals provide the foundation for the measurement process and are critical to its success. Incorrectly identifying the CARDS Program and/or subsequent project goals can produce disastrous effects on overall Program success.

Each goal is stated from a particular viewpoint. The viewpoint is a general term used to represent the interests of individuals involved with the CARDS Library System (i.e., CARDS team members, Project Leads, DoD customer, Program Manager, System Architect). The same metric could be interpreted differently, depending on whose viewpoint is being used. For example, Library Operations may need to know on a daily basis how the hardware is performing to make adjustments, while management may only need to know on a monthly basis whether the hardware continues to be adequate. The metrics that will be collected should be designed to answer concerns from each of these viewpoints.

Step one of the six-step process defines the goal matrices. Each goal matrix shows the relationship between two sets of goals (Customer Goals and CARDS Program Goals, CARDS Program Goals and Project Goals, and Project Goals and User Goals). The matrix Customer Goals/CARDS Goals lists all DoD Reuse Directives on the vertical axis and all CARDS Program Goals on the horizontal axis. The intersection of each DoD Directive and CARDS Program Goal shows what CARDS Program Goal supports which DoD Directive. More than one CARDS Program Goal may map to a DoD Directive and vice versa. For the purpose of metrics definition only those supporting goals that map to an individual goal are carried over to the next matrix.

CARDS Program Goals are carried over to the CARDS Goals/Project Goals matrix and are listed on the X-axis. (Note that this may represent a subset of the originally defined goals.) The intersection of the program and project goals shows what project goals support which CARDS Program Goals. More than one project goal may map to a CARDS Program Goal and vice versa.

Project Goals are then carried forward to the Project Goals/User Goals matrix, which shows what User Goal maps to a particular Project Goal. The intersection of Project Goal/User Goal lists the products and services that are provided. It is these products and services that are carried forward to the metrics matrices.

The content of the goal matrices is assumed to be somewhat stable. Program and project goals, once defined, are not expected to change drastically during the year. The effort to define these three matrices is expected to be a one-time effort with a yearly review for validation.

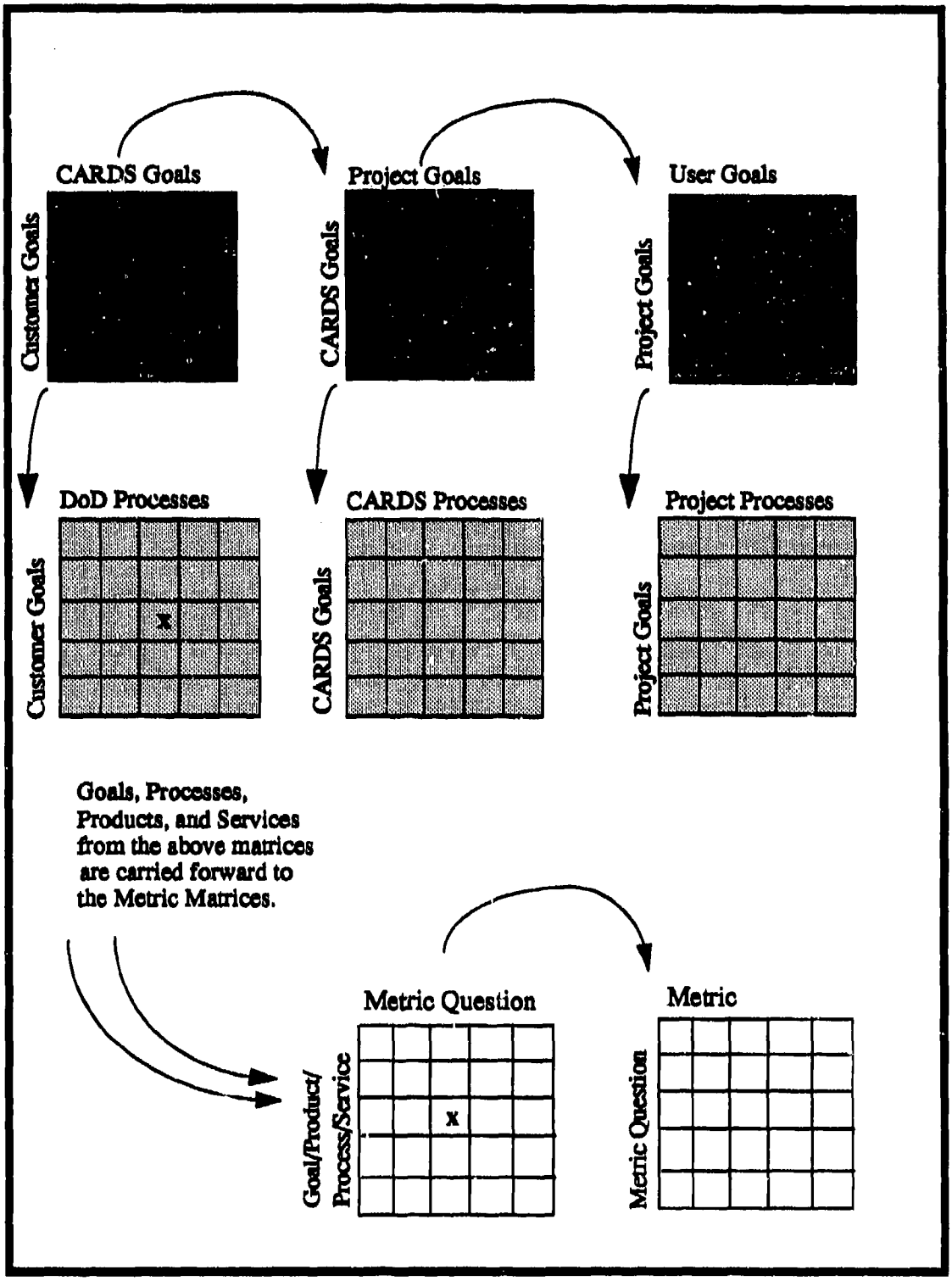

Figure 4-2. The Metrics Definition Framework

4.2.2 The Process Matrices

Measuring process steps is a very important part of the CARDS measurement process[1]. Improving a process for the purpose of defect reduction or to eliminate non-value-added steps will directly result in product and service upgrades as well as cost and schedule improvements. TQM activities are focused on process improvements where the owners (or users) of a process are responsible for improving it. For example, domain engineers own the domain engineering process and are responsible for continually improving it based on metric findings. The same focus on the process is noticeable in SEI's Capability Maturity Model [3] where the primary objective is to achieve a controlled and measured process as the foundation for continuous improvement.

The processes associated with defining, managing, implementing, and achieving each goal are listed in the process matrices. The goals from the goal matrices are carried forward to the process matrices which shows the relationship between processes and goals (Customer Goals and DoD Processes, CARDS Program Goals and CARDS Program Processes, and Project Goals and Project Processes). For instance, individual Customer Goals are listed on the vertical axis and supporting DoD Processes are listed on the horizontal axis. The intersection ("X") shows which process is used to implement a goal.

Step two of the six-step process defines the processes. DoD processes (such as contractual processes, procurement processes, or oversight processes) and user processes are outside the scope of the Metrics Concept Report. Only CARDS Program processes (such as processes for contract management, Technical Interchange Meetings (TIM), CARDS Configuration Control Board (CCCB) meetings, information dissemination, system growth management) and project processes (such as the domain engineering process, the Library release process, accounting processes) will be measured for process feedback.

The content of these matrices is assumed to be somewhat stable. Program and project processes, once defined, are not expected to change drastically during the year. However, process changes due to process improvements *are* expected. The effort to define these three matrices is expected to be a one-time effort with a yearly review for validation.

4.2.3 The Metric Matrices

Two more matrices are needed to complete the Metrics Definition Framework: the Goal/Product/Process/Service/Metric Question matrix, and the Metric Question/Metric matrix. The goals, processes, products, and services from the goal and process matrices are carried forward to the metric matrices. The metric matrices show the relationship between the goal, product, process, and/or services and the metric questions that can be asked on them and the metrics that must be collected to provide the answers.

---

[1] As can be imagined, there are many ways to achieve a result, only one of which is the desired or preferred one. For example, if the desired result is "25 new components in the Library", this could be achieved by (a) following a quality selection process, (b) taking the first 25 components to evaluate, (c) taking the 25 easiest components to evaluate, (d) dropping in any 25 components, and so on. Either process gives the result of "25 new components", but only one results in 25 quality components. Unless the process used to achieve the result is measured (i.e., made visible), management will never know. This is why it is so important to focus on the process. It also illustrates why it is fatal to a quality improvement program to measure people only by results.

The metric matrices are created in Step three of the six-step process. The Goal/Product/Process/Service/Metric Questions matrix shows what metric questions are asked. The Metric Question/Metric matrix shows what metrics are used to answer each metric question.

These two matrices are seen as evolving as the project matures, priorities change, and experience is gained with the measurement process. They need to be updated regularly.

4.2.3.1 Defining Metrics

Metrics can be broken into two categories: Result metrics and Contributor metrics. Result metrics ("Effects") are those management-oriented metrics by which the CARDS Program and/or a project area will be judged. Result metrics help determine if a goal is successfully achieved. For example, if the goal is to "significantly increase the contents of the Library as measured by # of components modelled", the result metric is "# of components installed". More than one result metric may exist for each goal or objective. To assist with manageability, it is important to identify the few significant metrics for each goal.

Contributor metrics are the technically oriented factors ("Causes") that influence judging. If the result metric is "# of components installed", contributing to this are various processes (such as searching for components to evaluate, evaluating components, formatting components in SGML) that must be undertaken to achieve the desired result. Each contributing process, in turn, is measured by its outcome (contributor metric, such as "# of components evaluated", "# of evaluation criteria to pass", "days to format in SGML"). There can be many contributing processes and metrics for each result metric.

Refinement is possible where the contributor metric becomes the result metric and smaller processes contribute to it. The relationship between result and contributor metrics can be documented in a Cause-and-Effect diagram (also known as Ishikawa diagram, or Fishbone diagram) as shown in Figure 4-3.The "Effects" are represented on the horizontal axis on the right side of the chart, and the "Causes" on the diagonal lines are listed on the left.

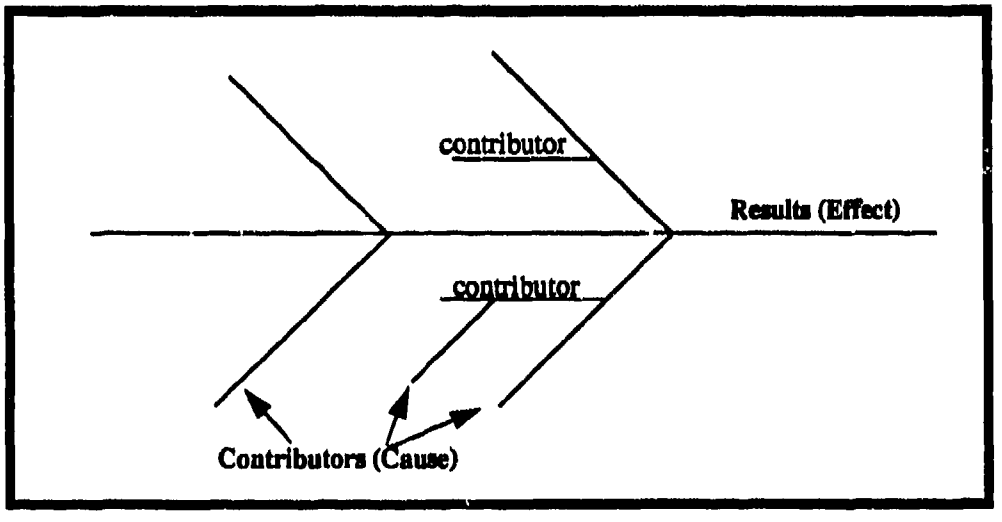

Figure 4-3. Cause and Effect Diagram

Once all matrices have been constructed they show how metric questions and metrics relate to the goal(s), products, processes, and services they support. Questions on goals, product and service quality can be asked at any level (the Result Metrics). Questions related to the processes (i.e., the contributing factors) used to achieve the goals, or to provide these products and services can be asked at the CARDS Program and project levels. Program and project goals flow downward to support the metrics, and data flows back to the originating question, issue, or concern. Maintaining goals using this framework makes it easy to add new metrics and metric questions. New goals can be added with immediate knowledge on the impact of the metrics definition.

5 The Metrics Definition Phase

Basili's GQM paradigm will be used during the Metrics Definition Phase. DoD, CARDS Program, and project goals and their associated processes are defined in the first three sets of matrices and carried forward to the last two matrices where metric questions and metrics are defined. A Metrics Definition Database to hold the information gathered is shown in chapter seven.

For each step in the six-step process, the *Purpose* of the step is listed, the *Participants* required for executing the process are identified, the *Input*, or preparation, necessary to execute each step's process is discussed, the *Process* to implement the step is addressed, and the *Output* from each step is presented.

5.1 Step 1: Define and Prioritize CARDS Program and Project Goals

5.1.1 Purpose

The purpose of this step is to define the context and foundation for the metrics to be collected. This step is critical to the success of the measurement process. The DoD vision, CARDS Program Goals, and associated goals for domain engineering, library operations, franchise implementation, franchise concepts, training, and reuse coordination, must be defined and prioritized. Users, customers, staff, and management have different needs and viewpoints which must be identified to isolate relevant experiences with the processes and on other projects.

5.1.2 Participants

The working group should be comprised of the Program Manager, the System Architect, Project Leads, the metrics analysts, and other CARDS team members as needed. Participants in the working group should be knowledgeable about the goals, products, and/or services to be measured.

5.1.3 Input

Input into Step one is any existing documentation on current goals, products, and services.

5.1.4 Process

The task of defining the goals and identifying viewpoints will be accomplished throughout a series of interviews and brainstorming sessions with CARDS team members. Several substeps are required to extract and/or define the goals. Separate sessions will be held for each of these focus areas:

- extract the Customer Goals;
- define the CARDS Program Goals;
- define the Project Goals. (Note: When desirable these goals can be refined to task level goals before metric questions and metrics will be defined);
- define the services and products provided by each project area; and
- define the User Goals. The start-up nature of this project makes it difficult to determine user goals. A suggestion is to derive user goals from the products and services provided by each project area.

The objectives of these brainstorming sessions are to:

- document Customer Goals as they apply to the CARDS Program;
- define and prioritize CARDS Program and project area goals;
- define the services and products provided by the project; and
- identify user goals.

Transition Technical Interchange Meetings (TIMs) will follow each brainstorming session to:

- validate the goals;
- update the next project team that will work on the next focus area on work already done; and
- educate CARDS team members who are not directly involved on progress made.

Several iterations of interviews, brainstorming sessions, and TIMs may be necessary to completely define each matrix.

5.1.5 Output

Goals will be documented in three matrices:

- Customer Goals/CARDS Goals: what CARDS Program Goals support the Customer Goals;
- CARDS Goals/Project Goals: what Project Goals support the CARDS Program Goals; and
- Project Goals/User Goals: what User Goals are supported by what Project Goals. Listed at the intersection are the products/services provided by the project area.

The matrix Customer Goals/CARDS Goals will list *all* program goals for the CARDS Program. There may not necessarily be a one-to-one correlation between DoD and CARDS Goals, or CARDS Goals and project goals. To keep the process manageable, the CARDS Goals/Project Goals matrix may actually be a set of matrices -- one for each of the CARDS project areas. Subsequent matrices will separately address metric questions and metrics for each CARDS project area. Note that the Metrics definition Database detailed in chapter seven would help significantly with the manageability of this effort.

5.2 Step 2: Define / Refine / Document the Processes

5.2.1 Purpose

The purpose of this step is to define and document the processes implemented in the CARDS Program or a project area. If the processes to be measured are already documented or if a product quality is being measured this step may be omitted. It is strongly recommended to measure processes, because only a change in process steps will result in a change in product and/or service quality.

All processes should be documented in as much detail as possible, whether or not metrics are collected. Basic process documentation is necessary for education or technology transfer. The level of detail to be documented for each process for metrics collection will depend on the detailed questions that may be asked about the process. However, documenting a process is a major effort and must not be underesti-

mated. Initially, metrics may only be collected at a very high level to gain baseline information thus alleviating the time consuming details of the documentation process.

5.2.2 Participants

The working group should be comprised of Project Leads, the metrics analysts, and other appropriate CARDS team members. Participants in the working group should be knowledgeable about the goals, processes, products, and/or services to be measured and be aware of the results of the measurement process so far. Members of the working group should also be familiar with basic process documentation techniques.

5.2.3 Input

Input into Step two is:

- the last two matrices defined in Step one (i.e., the CARDS Goals/Project Goals and Project Goals/User Goals);
- a list of processes selected by Program Management and Project Leads that are to be measured; and
- any existing documentation on those processes.

5.2.4 Process

Members of the working group will initially select the best documentation method (such as SADT, IDEF, or flowcharting) to be used for all processes to be defined. Use of the same methodology will promote consistency in understanding each others work and conveying correct information among the participants. This transfer of knowledge becomes critical during Step four (collecting metrics) of the measurement process.

Several working sessions will be required to document and review the processes. The objective of these working sessions is to document the processes.

A transition TIM will be held following this definition to educate the CARDS team and update the project team that will work on the next step. Follow-on working sessions to further refine the processes may be needed.

5.2.5 Output

The outcome of this effort is:

- two matrices (the CARDS Goals/CARDS Process and Project Goals/Project Process) showing which processes are used to define, manage, implement, and achieve each goal; and
- the documented processes themselves.

Due to the expected volume of process documentation, an individual may be [illegible] to help maintain this documentation.

5.3 Step 3: Define / Refine Metric Questions and Metrics

5.3.1 Purpose

The purpose of this step is to define the metric questions and their metrics, select the tools and techniques to be used to collect the metrics, set the standards of performance against which actual results will be compared, and define the reports and procedures for reporting actual results.

5.3.2 Participants

This working group should be chaired by the metrics analysts with members selected by the corresponding Project Leads. Participants of the working group should be knowledgeable about the goals, processes, products, and/or services to be measured and be aware of the results produced by the measurement process thus far.

5.3.3 Input

Input into Step three is:

- the previously defined matrices and processes; and
- existing metric questions and metrics.

5.3.4 Process

Several sessions will be required to define metric questions, metrics, collection methods, and reports for each goal, process, product, or service. The objectives of the working group are to:

- develop a set of metrics questions; and
- develop a list of key metrics to be collected.

For each metric that is to be collected, the working group will determine:

- assumptions, constraints, and other knowledge about the metric;
- the metric collection method (user feedback, system generated, from a log book);
- the metric's reliability, correctness, and validity;
- who will be responsible for collecting the metric);
- the standard against which the metric will be compared;
- how often the metric is to be collected and presented; and
- the format that will be used (i.e., report, graph, or list) to collect and present the metric.

A transition TIM will be held following this definition to educate the CARDS team and update the project team. Follow-on working sessions to further refine the metric questions and metrics may be needed.

5.3.5 Output

The outcome of this effort will be two sets of work products:

(1) two more matrices:

- Goal/ Product/ Process/Service//Metric Questions: which metric questions must be answered for which goal/process/service/product; and
- Metric Questions/Metric: what metrics support what metric question(s).

(2) a Metric Worksheet as shown in Figure 5-1 that shows for each metric:

- the goal the metric is tied to;
- the metric name and its measuring unit;
- the data source of the metric;
- the data collection method;
- the collection schedule;
- the responsible party to collect the metric;
- any assumptions and constraints known about the metric;
- the recommended standard for this metric,
- the justification for the standard; and
- any Program Management comments.

Goal / Objective:

Metric	Metric Unit	Data Source	Collection Method	Collection Schedule	Resp. Party

Assumptions, Constraints, and Other Knowledge about Metric:

Recommended Standard:

Justification for Standard:

Program Management Comments:

Figure 5-1. Metric Worksheet

6 The Metrics Implementation Phase

Steps four through six make up the Metrics Implementation Phase. Automated data collection reduces the overhead on the CARDS team members charged with collecting the data. It needs to be determined what data is already collected by a "tool" currently used (such as OS commands executed, terminal ID, date and time, amount of CPU time, etc.) and what data is recorded manually.

A separate effort, prioritized against other work, needs to be undertaken to determine what tools will be needed to automate the data collection, data submission, data storage, data analysis, and report functions. Tools such as Amadeus [16] to collect metrics data, and statistical analysis and presentation packages will be analyzed to assist in the automation effort. The effort required to automate these activities and manage the database needs to be justified by the effort required currently to manually collect, analyze, and present the data.

6.1 Step 4: Collect the Metrics

6.1.1 Purpose

The purpose of this step is to collect metrics to uncover, document, compile, and rank problems. Metrics help answer questions on current status, shortcomings, and future plans[1].

6.1.2 Participants

CARDS project team members executing the work processes in their day-to-day work will collect the metrics. Team members should be aware of all results produced thus far by the measurement process.

6.1.3 Input

Input into Step four is

- the Metric Question/Metrics matrix, and
- the Metric Worksheets developed in Step three.

If tools exist to automate data collection they must be implemented.

6.1.4 Process

CARDS team members will execute the work process, following the process steps documented in Step two. Process and product data will be collected as part of the day-to-day work activities. Data from the user should also be collected. The frequency of data collection, the collection method, and the responsible party to collect each metric are indicated on the Metric Worksheets for each metric. Some of the data collected can be used to provide real-time feedback to the project organization and the metrics analysts, for immediate process control. Care must be taken to ensure that data is not manipulated and that

---

1. Note that metrics will show the symptoms experienced by the user of a process or product/service, not a problem itself. For example, if a metric shows ten defects uncovered during testing, the problem is not that there are ten defects. The problem is most likely in the process used to produce the software.

consistency is maintained across the many sources of data. Given the expense of collecting data only data with a defined use should be collected.

6.1.5 Output

The output of this effort will be raw metrics data, stored on-line or on data sheets.

6.2 Step 5: Analyze the Metrics Data

6.2.1 Purpose

The purpose of this step is to identify the problems, rank them in some agreed-upon order, identify the root cause(s) of the problem(s), and suggest possible solutions.

6.2.2 Participants

The working group should be comprised of the CARDS Project Leads, the metrics analysts, and other CARDS team members. Participants of the working group should be knowledgeable about the processes, products, and/or services to be analyzed.

6.2.3 Input

Input into Step five is:

- the metrics collected in the previous step;
- all matrices developed in the Metrics Definition Phase; and
- the relevant Metric Worksheets.

6.2.4 Process

Various Quality Control (QC) techniques can be used to help identify and rank the major problems: Pareto charts, cause and effect diagrams, scatter plots, check sheets, pie charts, histograms, graphs, and/or control charts. The team will decide which technique best suits its needs. Various criteria, such as severity, frequency, and/or cost can be used to determine the priority with which problems should be addressed. The team must also identify the root cause(s) of the problem(s) by identifying all process components related to creating the problem[1]. This is where analysis of the metrics *within the context in which they were collected* will yield valuable information for process improvements. Related program issues and risks, corrective action plans, standards, training/skills, and procedures could all be related to the problem. Finally, the working group must identify and suggest possible solutions and the best way to implement change.

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[1] Identifying and ranking the problem is *product/service* related. Identifying the root cause and suggesting a possible solution is *process* related.

6.2.5 Output

Output from this step will be the various QC charts, as well as suggestions for process improvements. Regular Program Management Reviews (PMRs) for CARDS will provide visibility for this effort.

6.3 Step 6: Act on Results

6.3.1 Purpose

The purpose of this step is to gain management approval to implement the identified change[1], to take possible short-term action, and to implement long-term solutions in process improvements.

6.3.2 Participants

This group should be comprised of the Program Manager, the System Architect, and Project Leads.

6.3.3 Input

Input into Step six is the analysis work done in Step five.

6.3.4 Process

CARDS Program Management must make it a priority to actively address issues revealed by metrics. The Program Manager will approve recommended process changes before they are implemented. Implementing the solution can be broken into short term and long terms activities. Since process improvements may take several weeks or months to complete, the team should implement any action items that can be accomplished in the short term (such as inserting a warning message, installing a workaround). Any process changes must be verified to ensure that the desired result is indeed achieved. This may mean cycling back to Step four, "Collect metrics" and comparing the new results with the old ones.

6.3.5 Output

Process changes must be documented as outlined in Step two. Reuse experience and lessons learned through metrics collection will be added to each CARDS project area. Charts depicting product growth over time and associated confidence levels will be maintained.

---

[1] The criteria used to approve a solution must be stated to the team *before* work is done on problem analysis and a solution is suggested. Disagreeing with a solution at this step because the wrong evaluation criteria were used means the team has to go back to Step five. This wastes time. To say nothing of the frustration to the team.

7 Added Value Through Automation

A relational database can be developed to help the metrics definition process. An application with views into the database can be developed that steps through the process of defining the goal, process, and metric matrices.

The design of the Metrics Definition Database is depicted in Figure 7-1. Goals, processes, services and products, as well as the associated metric questions and metric definitions are stored in the database. The metrics analyst can thus easily compare new items to those already defined in the system. Changes to the definition of any part of the system can be traced to all affected parts through links defined in the relational database.

If an automated metrics collection tool such as Amadeus is used, and links between the collection tool and the metrics definition database are possible, then the Metrics Definition Database could be used to drive an automated collection of metrics data. Statistical analysis packages to help with the data evaluation, and presentation packages should also be evaluated for automation. This will be further addressed in each project area's *Metrics Plan*.

7.1 The Metrics Definition Database

Goals are defined in "G" tables. The Customer Goals are stored in the G1x table, the CARDS Program Goals are stored in the G2x table, and the DoD/Cards Program Goals matrix is stored as the G1x-G2x table. Each record in the G1x-G2x table corresponds to one element in the matrix. CARDS Project Goals are stored in the G3x table, and the relationship between the Program and project goals is stored in the G2x-G3x table. This corresponds to the second matrix "CARDS Program/Project Goals." User Goals are stored in the G4x table and the relationship between user goals and project goals is stored in the G3x-G4x-S4x table. This table corresponds to the third matrix "Project Goals/User Goals," the intersection of which lists the products/services provided.

Processes are defined in "P" tables. The P2x table contains the processes used at the CARDS Program level and the G2x-P2x table corresponds to the CARDS Program process matrix which lists the processes used to support the CARDS Program goals. The P3x table contains the CARDS Project processes, and the G3x-P3x table corresponds to the CARDS Project process matrix which lists the project processes needed to support the project goals.

Metric questions and metrics are defined in the "Q" and "M" tables respectively. The Metric Question table contains the questions derived from the goal, process, or product/service statements. The Mx table contains the metrics definitions and the source of each metric, the frequency of collection, the responsible party, and other information from the Metric Worksheet.

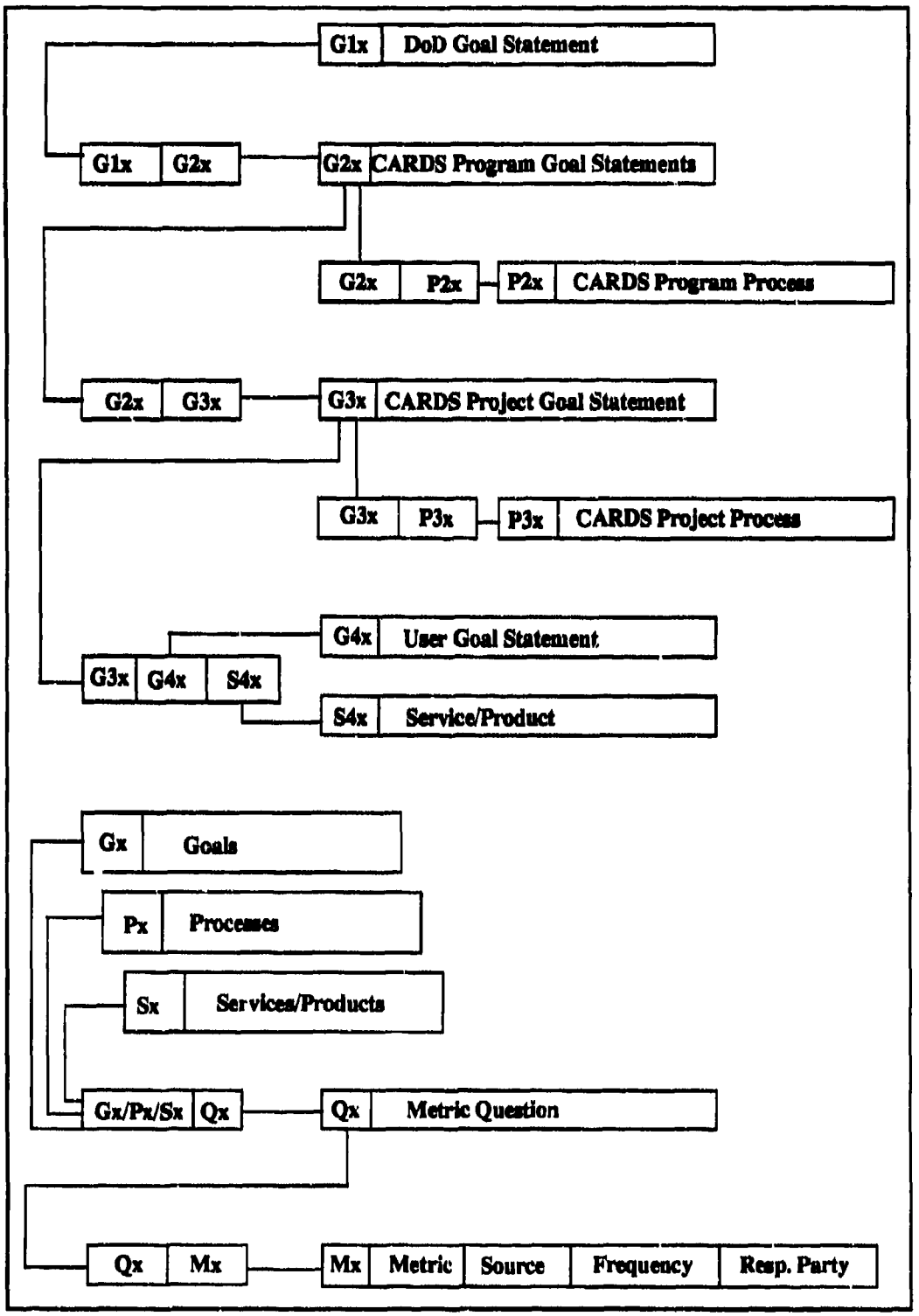


Figure 7-1. Metrics Definition Database

8 Conclusion

It is the overall *measurement process* not just the graphs and reports that adds value to the data. The six-step process outlined in this document is integral to the CARDS Program and shows how the knowledge about the data, the goals the data is tied to, and the viewpoints affected are all necessary to understand what the data means and how it is to be used. As the measurement process is being implemented, lessons learned from it will be used to further refine it. This requires active management commitment and support. To successfully implement the measurement process, it is necessary to:

- know what the goals are. They drive the measurement process and the CARDS Program;
- identify the key metrics by which the CARDS Program will be evaluated;
- apply the discipline to follow documented process steps. If steps are skipped, the process becomes unknown and its data will be useless;
- collect metrics on CARDS processes to help make these processes visible and thus become a candidate for process improvement. Process improvements will result in product and service improvements, as well as cost and schedule improvements; and
- automate as much as possible the definition, collection, analysis and reporting of the metrics.

As CARDS processes continue to mature the challenges faced by the CARDS team include evolving the measurement process and devising methods that compensate for differences in data collection and reporting among the eleven companies comprising the CARDS team. The CARDS team is also faced with conceiving new and creative ways of measuring the level of user satisfaction with the CARDS Library System.

The effort needed to define the goals and processes is significant and can easily span a year or more. In the meantime, baseline measures can be taken in some project areas (such as in Library Operations) to gain an understanding of where process improvements are possible. A phased implementation to gain experience with the measurement process is also recommended.

8.1 Next Steps

The first CARDS Project Area to benefit from the six-step measurement process will be the CARDS Library System. Metrics are already collected in isolated areas, such as in Library Administration. The six-step process will take advantage of already existing metrics and build from there. Given the time schedule (Phase III will be completed the end of March 1994), only a subset of metrics will be collected. Due to the expected effort and time required to define the goal and process matrices, the initial effort will focus on key issues that have already been identified, such as the Library release process, SCR/STR metrics, graphical presentation of metrics, and automation needs. Parallel to this activity, high-level goals will be extracted and defined. Matrices will thus be filled in from the top and the bottom. Once work has been documented in this fashion, additional goals and metrics can be defined.

Appendix A A Framework to evaluate a Metric Program's Success

The table below lists the assessment criteria that can be used to evaluate the metrics program at CARDS. These questions can be used to periodically evaluate the CARDS Program, noting improvements. These criteria are taken directly from Jeffrey & Berry [10]. A scoring mechanism of:

0= does not meet any of the requirement

1= meets some of the requirement

2= meets most of the requirement, and

3= fully meets the requirement

could be applied, with equal weight given to each question. This assessment could be performed before establishing metrics in a particular CARDS project area, and then periodically to help determine how successful the metrics program at CARDS is.

Table 3: "Context" is the environment in which the CARDS Metrics Program is being developed and operated.

Question	Comments
Are the goals of the CARDS measurement program congruent with the goals of the CARDS Program?	CARDS measurement goals are an integral part of the CARDS Program. Chapter 4 shows how metrics are tied to CARDS Program and project goals.
Are the objectives and goals for the CARDS measurement program clearly stated?	Goals and objectives for the CARDS measurement program are defined in chapter 2 of this document.
Does the CARDS measurement program have a realistic assessment of pay-back period?	The length of the payback period will depend on the number and depth of process improvements identified and implemented. Metrics to help estimate the start-up cost of building a reuse Library need to be established for franchises.
Does the measured staff participate in the development of the measures?	Staff will not be measured. Staff, however, should participate in the metrics definition and implementation process and help with the analysis process.
Has a quality environment been established?	Quality is stressed throughout the CARDS Program.
Are the processes stable?	Many processes such as the domain engineering process are still being defined. Processes must be repeatable for metrics collection and analysis to be effective.
Can the required granularity of data to be collected be determined and is the data available?	Data granularity is determined by the metric questions asked on a particular goal, process, product, or service. Data is available today in Library Operations. Data on other project areas will become available as the measurement process matures.

Table 3: "Context" is the environment in which the CARDS Metrics Program is being developed and operated.

Question	Comments
Is the measurement program tailored to the needs of the organization?	The metrics definition framework is designed to be tailorable.
Is senior management commitment available?	Senior management has stated its commitment repeatedly.

Table 4: "Process" is the method used to develop, implement, and maintain a CARDS Metrics Program.

Question	Comments
Process Motivation and Objectives	
Is the program promoted through the publication of success stories and encouraging exchange of ideas?	CARDS does many publications to exchange ideas on reuse. Metrics success stories are not yet published.
Is a firm implementation plan published?	This document provides the foundation for the CARDS Metrics Plan.
Does the program assess individuals?	Metrics should never be used to assess individuals.
Process Responsibility and Metrics Team	
Is the metrics team independent of the software developers?	An independent metrics team can concentrate on metrics definition and help with the analysis in a less biased manner. The metrics analysts are independent of the development team.
Are clear responsibilities assigned?	Project Leads are responsible for assigning project responsibilities. Key individuals are assigned the responsibility for the metrics concept implementation.
Is the initial collection of metrics sold to the data collectors?	Staff collecting the data must know why the data is collected, and what the data is used for. This will help establish a positive attitude towards data collection. Staff will participate in the metrics definition as outlined in chapter 4.
Process Data Collection	
Are the important initial metrics defined?	Some metrics are defined through internal agreements with government program representatives.
Are tools for automatic data collection and analysis developed?	Yes. Locally developed scripts are used in Library Operations. More needs to be done such as the evaluation of Amadeus and similar tools that facilitate collection and on-line presentation.
Is a metrics database created?	Not yet. A Metrics Definition Database is proposed in this document. A database containing metrics data should also be developed.

Table 4: "Process" is the method used to develop, implement, and maintain a CARDS Metrics Program.

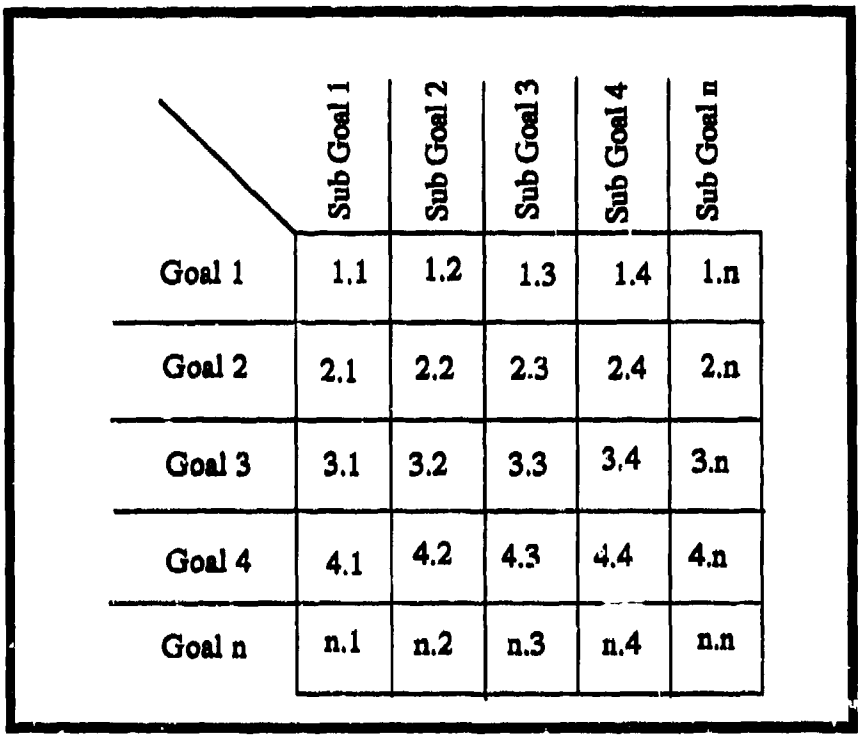
Question	Comments
Is there a mechanism for changing the measurement system in an orderly way?	The Metrics Concept Report proposes the use of Basili's GQM paradigm to define metric questions and metrics. The Metrics Plan will outline the process for controlled changes to software and management processes based on metrics findings. The proposed database will help identify all goals, questions, and metrics affected by changes to any of these components.
Is measurement integrated into individual CARDS processes?	To provide useful information on process improvements, metrics must be part of a process, not separate from it. Metrics are integrated into Library Operations processes and must be integrated into the other project area's processes.
Are capabilities provided for users to explain events and phenomena associated with the project?	Measurement without context can be misleading. Metrics must be evaluated in light of assumptions, constraints, and other knowledge for a true picture to emerge. The metric worksheet proposed in Chapter 5 helps maintain pertinent information for each metric.
Is the data collected cleaned i.e., normalized, and used promptly?	Data is not currently normalized. Metrics collected in the Library Operations area are used in PMR presentations, but not otherwise. As the measurement process is implemented, data will be used to help with process improvements. Impact assessments and recommendations are needed in all project areas.
Do the CARDS Program Goals determine the measures?	Chapter 2 of this document outlines the Basili GQM paradigm. Chapter 4 shows how to tie CARDS Program goals to metrics.
Process Training and Awareness	
Is adequate training in metrics carried out?	Training in the purpose and use of metrics is required for everyone involved with the CARDS Program. Management must make data-based decisions, staff must understand the collection and help with the analysis, and Project Leads must change process steps based on metrics findings. The measurement plan outlined in chapters 5 and 6 shows where informal TIMs are to be used to train anyone involved in metrics.
Does everyone know what is being measured and why?	As metrics are defined in each project area, everyone's help will be needed to improve the processes for better products and services. This involvement will provide individuals with insight into what is being measured and why.

Table 5: "Products" are the measures taken on CARDS products, services, and processes, the reports produced, and other outputs of the Metrics Program.

Question	Comments
Are the measures clear and of obvious applicability?	Basili's GQM paradigm ties measures to their goals. Knowing what the question is, and which goal it is tied to, helps to clearly define the metrics that must be collected.
Do the measures taken provide clear benefits to the management process?	Only Library Operations currently collects metrics. Metrics must be defined that will impact the management processes in all CARDS project areas.
Is feedback on results provided to those being measured?	Processes, services, and products are measured, not people. Those collecting metrics on a process, product, or service must also receive the results of the metrics analysis to understand management decisions and add analysis details ("context") to the data.
Is the measurement system flexible enough to allow for the addition of new techniques?	Yes.
Are measures used only for pre-defined objectives?	Metrics that are not tied to goals and objectives of the CARDS Program and processes yield no useful information.

Appendix B Interoperability

This appendix is an example that shows how information gained from the interoperability project is used to construct a set of five matrices. The matrix numbering scheme is shown in Figure B-1.



	Sub Goal 1	Sub Goal 2	Sub Goal 3	Sub Goal 4	Sub Goal n
Goal 1	1.1	1.2	1.3	1.4	1.n
Goal 2	2.1	2.2	2.3	2.4	2.n
Goal 3	3.1	3.2	3.3	3.4	3.n
Goal 4	4.1	4.2	4.3	4.4	4.n
Goal n	n.1	n.2	n.3	n.4	n.n

Figure B-1 The Matrix Numbering Scheme

If Sub Goal 1 is supported by Goal 1, an "X" will be placed in position 1.1. If Sub Goal 1 is also supported by Goal 3, another "X" will be placed in position 3.1.

Some notes on the following matrices:

- where possible, direct statements were taken from supporting documents. No effort was made to refine existing metrics;
- goals are often not explicitly stated. In that case, goal statements were extracted.
- the documentation [1 and 4] does not state how these goals are supported (i.e., the CARDS Program processes). The intersection in the following matrices shows a simple "X" where processes should be.

B.1 DoD / CARDS Goals

DoD Software Reuse Vision and Strategy (July 15, 1992):

"Interoperability should provide the ability to locate and share reusable *[assets]* across domains and among services. Utilize evolving technology to provide a network of interconnected reuse library systems to support capture, storage, and reuse of *[assets]* within and across specific domains"

CARDS Interoperability Goals (extracted):

Use LIS, the Library Interoperability Service, to provide interoperability services to CARDS users (by giving them access to remote assets) and to users of cooperating libraries (by providing them access to CARDS assets).

The DoD Goals/CARDS Goals Matrix will look as follows:

DoD Goals \ CARDS Goals	Interop. to CARDS users	Interop. to cooperating libraries	use LIS client/server
locate, share reusable assets	X	X	
Use evolving technology			X

Figure B-2 DoD Goals/Cards Goals

All CARDS Goals are carried forward to the next matrix.

B.2 Interoperability Project Goals

Provide automated access to remote assets for CARDS users, including:

retrieve and display the abstract of a remote asset;

retrieve and display the description of a remote asset; and

retrieve the contents of a remote asset and store them in the users library.

Provide automated access to CARDS assets for users of cooperating libraries, including:

provide the abstract of the CARDS asset;

provide the description of the CARDS asset; and

provide the contents of a CARDS asset.

Collect usage and performance metrics to assess the impact of interoperation on their respective library operations.

The CARDS/Project Goals matrix will look as follows:

CARDS Goals \ Project Goals	automate access to remote assets	auto access to CARDS assets	collect metrics
Interop to CARDS users		X	
Interop to cooperating libraries	X		
Use LIS client/server	X	X	

Figure B-3 CARDS Goals/Project Goals

Note that "collect metrics" is not tied directly to any CARDS goal. This goal could be restated as "implement an efficient client/server mechanism" which would require metrics collection to demonstrate efficiency. Stating the goal this way also gives a tie back to *why* metrics are collected.

B.3 User Goals

Assets exported from CARDS:

Service Provided: msg_driver_motif; BB_PRISM_msg_gen; PRISM_MTV; PP; XSpread.

Assets imported from ASSET:

Service Provided: Ada/SQL Bindings; OPTIMIZATION AND PLANNING TOOLS; REUSABLE IMAGE PROCESSING PACKAGES

Assets imported from DSRS:

Service Provided: Screen_And_Data_Manager; Generic_Report_Handler; Safe_IO; String_Utilities

The Project Goals/User Goals matrix will look like this:

Project Goals \ User Goals	exported by CARDS	imported from ASSET	imported from DSRS
auto access to remote assets	X	X	X
auto access to CARDS assets	X	X	X
collect usage and performance metrics			

Figure B-4 Project Goals/User Goals

Project management's goal of collecting usage and performance metrics is not reflected in any user goal, and thus no products or services are found at these intersections. If this goal was restated as "implement an efficient client/server mechanism," the intersections would show such products as TCP/IP or LIS client/server. Measurements could then be collected on these products/services. For the purpose of this discussion, all goals will be carried forward to the next matrix.

B.4 Metric question

- What is the current composition of a library's set of available extractable assets?
- How many searches are performed at the library and how many hits result from these searches.
- How many requests are made to browse abstracts for assets in the library? What is the efficiency of accessing the requested abstracts?
- How many requests are made to extract an asset from the library?

The only performance metric question asked which refers back to the process steps used to access the library is on the "efficiency of accessing abstracts." (After discussing this with the Project Lead, this may be a typo in the original document [CARDS04].) Additional performance questions should be asked. Detailing the process steps will allow us to get at these additional metric questions.

The Metric Goals/Metric Questions matrix will look like this:

Metrics Quest. / User / Product Goal	current composition	how many searches	how many hits	how many requests for abstracts	efficiency of accessing abstracts	# of requests to extract asset
usage and performance metrics	X	X	X	X		X
Interop to CARDS		X	X			
Interop to coop. Libs		X	X			
exported by CARDS	X			X		X
imported from ASSET	X			X		X
imported from DSRS	X			X		X

Figure B-5 Metric Goals/Metric Questions

B.5 Metrics

for available assets:

number of local extractable assets

number of remote extractable assets (from each library)

total number of extractable assets

for searches:

total number of searches

number of non-null searches

number of null searches

number of local hits

number of remote hits

for abstract requests:

number of local abstract request

number of remote abstract requests (from each library)

number of failures

average, min, and max abstract transfer times

average, min and max abstract size

for asset requests:

number of local asset requests

number of remote asset requests (from each library)

number of failures

avg, min, and max asset transfer times

avg, min, and max asset size

For readability, the Metric Question/Metrics matrix has been rotated to list the metrics on the vertical axis:

Metric \ Question	current composition	how many searches	how many hits	how many requests for abstracts	efficiency of accessing abstracts	# of requests to extract asset
local assets	X					
remote assets	X					
total # of assets	X					
# of searches		X				
# of non-null search.		X				
# of null searches		X				
# of local hits			X			
# of remote hits			X			

Metrics Question/Metrics matrix, cont'd:

Metric / Quest. / Metrics	current composition	how many searches	how many hits	how many requests for abstracts	efficiency of accessing abstracts	# of requests to extract asset
# of local abstract requests				X	X	
# of remote abstract requests				X	X	
# of failures				X	X	
avg/min/ max xfer rate					X	
avg/min/ max xfer size					X	
# of local asset requests						X
# of remote asset requests						X
# of failures						
avg/min/ max asset xfer times						
avg/min/ max asset size						

Figure B-6 Metric Question/Metric

Note that several metrics are collected that have no corresponding metric questions. This matrix indicates which set of metrics are needed to answer a particular question. It also shows that other questions could be answered, such as "what is the percentage of failures", or "is the trend to access assets increasing over time?"

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